

CLASSIFICATION OF VENUS SURFICIAL UNITS USING MAGELLAN DATA J. J. Plaut, Jet Propulsion Laboratory, California Institute of Technology, MS 183-501, 4800 Oak Grove Dr., Pasadena, CA, 91109; email: plaut@jpl.nasa.gov.

Interpretation of the nature of the geologic materials exposed on the surface of Venus requires analysis of the multiple radar and emission data sets acquired by the Magellan spacecraft. Three separate experiments carried out by Magellan provide these data: radar imaging (SAR), radiothermal emission, and altimetry. The SAR images provide details of the morphology and setting of surface features, as well as quantitative measurements of radar backscatter, which is controlled primarily by wavelength-scale surface roughness. Emissivity, to first order, is controlled by the dielectric constant of the upper surface, with a secondary influence from surface roughness. The altimetry experiment provided estimates of surface Fresnel reflectivity, which was observed to closely track the unit complement of emissivity [1], and of meter-to-decameter rms slopes, based on a model of quasi-specular radar scattering.

The largest variance among these data sets is seen between the SAR backscatter and emissivity. Each altimetry-derived data set correlates strongly with one of these two data sets, although the rms slope occasionally shows a divergence from SAR backscatter, due to some scale-dependence of surface roughness and inherent differences in scattering mechanisms between the two experiments. For this exercise, the SAR and emissivity data are used in a simple supervised classification algorithm to delineate surficial property “units” as an aid to geological interpretation. This technique allows merging and visualization of information from the two data sets. Local surficial units can be identified, which are often closely related to geologic units identified in the geologic mapping effort. Similarities in scattering and emission behavior at widely separated locations across the planet are potentially useful for correlation of geologic units. Striking differences in the distribution of the units are observed across the planet, implying the existence of distinct “provinces” of surface property types.

The classification scheme is obtained by “slicing” the histograms of both SAR backscatter and emissivity into three segments, based on the global behavior. The histograms are divided into the lower 20% (low), middle 60% (medium) and upper 20% (high) categories, and a 3x3 matrix of these categories results in 9 classes of scattering and emission behavior. Cutoff values for the SAR data were 3.2dB less and 1.8 dB more than the Muhleman law standard [2] and for the emissivity data, 0.829 and 0.874. Preliminary analysis was conducted on Mercator projection data at 4.6 km/pixel resolution between latitudes of $\pm 66.5^\circ$. The following table shows the unit designations (numbers) for each combination of backscatter and emissivity:

	Low emis.	Med. emis.	High emis.
Low SAR	1	2	3
Medium SAR	4	5	6
High SAR	7	8	9

Unit 1, low SAR and low emissivity (S-L, E-L) is limited almost exclusively to the impact-related parabolic features. The relatively high dielectric constant [3,4] and the low backscatter on these features is a unique combination which stands out clearly in the classification map. The unit is not evenly distributed around the planet; rather it is concentrated in the low latitude plains regions between about 0° and 110° E longitude.

Unit 2 (S-L, E-M), is broadly distributed on plains surfaces. It is normally associated with impact craters that have a slight or no emissivity anomaly compared with Unit 1 parabolas. Some dark plains in Unit 1 have no clearly associated impact feature. These areas may be simply smooth lava plains, or surfaces mantled with material from distant impacts or other sources.

Unit 3 (S-L, E-H) is found on only 1.2% of the surface. This implies that deposits of loose, low density material are rare on Venus because such materials should be expected to have low backscatter and high emissivities (i.e., low dielectric constants). Campbell [4] noted the occurrence of low dielectric surfaces near impacts at Gula Mons, and possible volcanic deposits at Tepev and Maat montes. Surfaces with similar characteristics are seen in this unit south of Phoebe Regio, north of Tellus Regio and west of Artemis Corona. The Phoebe occurrence appears to be related to lava flows whose source region contains several steep sided domes.

Unit 4 (S-M, E-L) has three modes of occurrence: brighter portions of impact parabolas, at moderate elevations on certain highlands, and on lava flows in the Guinevere-Navka plains region. The highland examples appear to result from a combination of decreased roughness and higher emissivity that lowers the SAR backscatter from the brightest levels seen in highly reflective areas. The concentration of moderately high dielectric lava flows in the Guinevere-Navka area distinguishes this as a unique volcanic “province” on the planet.

Unit 5 (S-M, E-M) is by definition the typical Venus surface, covering about 40% of the map. It normally corresponds to the “regional plains” units mapped by several workers, although younger lava flows related to coronae and other sources also occur within the unit.

Unit 6 (S-M, E-H) is usually found on plains surfaces in the vicinity of ridge or fracture belts. The most prominent occurrences are in the Pandrosas-Vinmara ridge belt area and southwest of Lakshmi Planum.

Unit 7 (S-H, E-L) includes the well-known reflective highland areas [1]: Ovda, Thetis, Atla and Beta regiones, and Maxwell Montes. Two areas of Unit 7 that have higher emissivities than the highlands, but still in the lower 20th percentile, are the Guinevere-Navka volcanic province. and broad area south and east of Ulfrun Regio.

Unit 8 (S-H, E-M) includes most impact craters, parts of some tessera areas, and moderately disrupted zones, such as corona rims and segments of ridge and fracture belts. In the

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Navka area, this unit corresponds well to areas mapped as deformed plains by [5]. Lava flow occurrences of this unit may have slightly elevated dielectric constants which lower the emissivity to normal levels from the expected (based on high backscatter) roughness-related effects.

Unit 9 (S-H, E-H) occurs on the most heavily disrupted zones on the planet, which are not at high enough elevations to display low emissivities. This includes most tessera occurrences, the Artemis-Dali-Diana chasmata system, and the Pandrosas ridge belts. Lava flows are rare in this unit, with the prominent exception of the “Australia-shaped” flow south of Lakshmi Planum. Fracturing of rocks at the wavelength scale in response to tectonic deformation is thought to produce the rough SAR and emissivity signatures of these units. Analysis by [4] suggests that these surfaces may also have slightly lower dielectric constants, contributing to the high emissivity.

Examination of a map of the surficial unit classes indicates that the planet has several distinct surficial unit provinces. Lava flows in the Guinevere-Navka area appear to have a unique low emissivity character. Unit 1 parabolas are clearly concentrated in the region north and west of Aphrodite Terra. High emissivity plains (Unit 6) are localized around Lakshmi and the ridge belts to the west, although the distribution of this unit needs to be re-examined taking into account to observed increase in emissivity with decreasing emission angle (i.e., higher latitudes). This refinement and a possible fine tuning of the histogram slice levels should improve the utility of the classification.

REFERENCES: [1] Pettengill et al., 1992, JGR 97, 13091-13012. [2] Saunders et al., 1992, JGR 97, 13067-13090. [3] Plaut and Arvidson, 1992, JGR 97, 16279-16292. [4] Campbell, B., 1994, Icarus 112, 187-203. [5] Plaut, LPSC XXVII, 1039-1040.